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A DAMAGE ASSESSMENT MODEL FOR SURFACE ENGAGEMENT FOR MISSILE AN--ETC(U)
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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A Damage Assessment Model for Surface Engagement for Missile and Gunfire

by

Mario Ivan Carratu Molina

March 1982

Thesis Advisor: Wayne P. Hughes, Jr.

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The hits on a target are assumed to be distributed uniform-randomly along a target's length. Target elements (gun mounts, communications propulsion, etc.) are degraded or destroyed according to assigned vulnerability factors. To exercise the model, when experimental data was not available, judgmental inputs were used. The resulting outputs were realistics. The model uses a computer program written in Fortran four with Montecarlo features incorporated.

A DAMAGE ASSESSMENT MODEL FOR SURFACE ENGAGEMENT FOR MISSILE AND GUNFIRE

BY

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VENEZUELAN NAVAL ACCADEMY, 1965

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I would like to express my gratitude to Captain (USN) Wayne Hughes, Jr. and to Dr. Alvin Andrus for their assistance, guidance and encouragement which they provided to me during the pursuit of this work. I also want to dedicate my work to my lovely wife Betsy and to my sons Mario Ivan and Juan Carlos for their patience, understanding and fortitude given to me during my studies at the Naval Postgraduate School.

I. INTRODUCTION

A war game is a dynamic presentation of military actions executed in such a way that one or more human participants can exercise control and take decisions against the activities of opposing forces in a real or hypothetical scenario. There are essential elements in war games which distinguish them from other simulations of military acti - ties. They are:

a. Force command and control (the combat decisions) f the opposing forces are made by human decision-make:

b. These decision-makers must react to the evolution of the combat and exercise their capabilities and experience in order to take decisions that later will reflect their accuracy or not in the outcome of the battle.

These characteristics make war games perhaps the only medium available, short of war, efficient enough for evaluating and examining command decisions at every level as well as constituting a tool to identify and isolate problems such as weapons limitations, forces weakness, logistic requirements, command and control, etc., as they arise during the execution and conduct of the operations; and in addition, the affect of the environment where forces are supposed to enact. More generally, a war game is a simulation, which is operated in accordance with predetermined rules, data, and procedures for selected aspects of a conflict situation.

Simulation also provides a means for gaining experience, and the development of analytical expertise and awareness of the systems available, without paying the penalities of a real world conflict.

In order to fulfill their objectives, war games must be realistic and reflect at every moment the sense of real conflict situations, where the players have the opportunity to exercise their skills in dealing with the variables in play. The author believes that one of the key points which contributes to the realism of the games is to have an accurate Damage Assessment procedure, from which people involved in the game could evaluate operational and tactical outcomes with respect to the decisions that they make.

In order to obtain this degree of realism, the people in charge of the damage assessment role must have valid and accurate information pertaining to vulnerability, reliability, accuracy and destructive power of weapons systems under consideration, as well as an unbiased appreciation of the power and weakness of the opposing forces. In addition, the players must be able to use the outcomes of the damage assessment process to develop capabilities and techniques to evaluate the performance effectiveness of the systems on hand and to take the optimal decision that the tactical situation and the ongoing operations require.

For the case of naval forces in a combat situation, it is necessary to have a means of assessing the damage to the

combatants as a function of their respective forces composition. The specification of such a damange function is not an easy task because of the varied roles that different force types play; and also because the interactions between force types can vary considerably with respect to the different characteristics which will add more complexity to the model.

This work presents a particular view of Surface Damage Assessment by considering Missile and Gunfire. The author uses a Monte Carlo technique in a stochastic process in which two opposing surface forces of one or more ships (Blue and Red) engage in a gun and missile battle.

The expected damage for each force is assessed by considering the following variables:

A. Expected Damage Given One or More Hits.

B. Target Aspect (angle).

C. Rate of Weapons Fire.

D. Jamming Factor.

E. Weapon Hit Probability as a Function of Range.

F. Sea State.

The simulation program combines a deterministic expected value model and chance elements by means of a routine written in Fortran IV using an IBM 3060 computer.

The Damage Assessment model will now be discussed in detail, followed by a description of how the variables were considered. A practical example of its implementation is then shown.

II. DAMAGE MODEL

This chapter presents in detail the method followed in the development of the model. It also describes the factors taken into consideration in order to keep a sense of both realism and consistency.

The absence of a mathematical expression which permits the damage calculations and the variety of variables and parameters which has to be considered (e.g., platforms type, weapons, number of units) make the work difficult to accomplish, and it requires a great deal of research and real world experience to give the analyst the necessary background to cover all the areas of importance.

A. GUNFIRE DAMAGE MODEL

The work was conducted using the bibliography available at the library of the Naval Postgraduate School. However, most of the material in this field is classified. Therefore it was necessary to create hypothetical, but reasonable, data in order to build the foundations to support the model. The damage calculations are realistic, but will not be necessarily accurate in detail until experimental data are obtained. The factors which were considered in the model are:

1. Target Aspect Factor (angle)
2. Hit Probability as a Function of Range

3. Expected Damage Given a Hit as a Function of Target Size
4. Sea State
5. Deceptive Jamming Factor
6. Weapons Rate of Fire

Each factor is presented in the following section with discussion as to how they were considered for model purposes.

1. <u>Target Aspect Factor</u>

For the purpose of the model, target aspect is the relative position of the target with respect to the opposing ship. It is defined as:

> The smallest angle between the line of fire and the center line of the target ship.

The line of fire is the bearing of the point of aim from the center of the firing ship. If this line is within a given number of degrees, it will be an indication of the relative position of the target and the firing ship will have an angular value which reflects the characteristics of the ships considered.

In order to implement this factor into the model, a target size was chosen that was the average for the most common ships.

length	500 feet
width	55 feet

The next step was to combine target angle with the range in order to obtain a numerical value called Target Aspect

Factor which reflects how the relative angle and range of the target, with respect to the attacking ship, will affect the accuracy of the delivery of weapons.

The next step was to have a base range which was used as indication of position of the forces. It was necessary to split the range in three sections as follows:

Long Range = .9* Effective weapon range

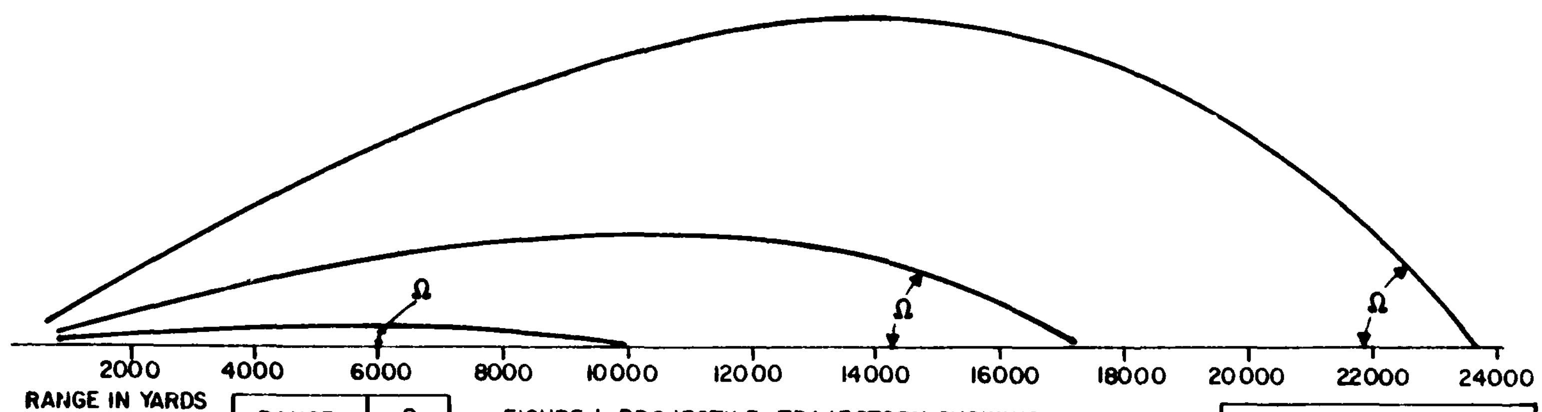
Medium Range = .6* Effective weapon range

Short Range = .3* Effective weapon range

When the target range falls closest to the above values, then it is said that the target is at long, medium, or short range, respectively.

In order to combine Target Range and Target Angle, a mathematical relationship was developed by considering: Target Length, Target Width, and Target Angle, and the value of the angle formed by the projectile trajectory and target vertical plane. This angle will be called from now on the "Incidence Angle" (Omega). In order to determine the values for the incidence angle, it was found in the trajectory tables for 6 inch guns that this value changes with the range. The values were selected for long, medium, and short range; see Figure 1.

For long range, the Omega value was 45 degrees. For medium range the Omega value was 15 degrees. For short range the Omega value was 3 degrees. The relationships expressed above are:



RANGE	Ω
SHORT	3°
MEDIUM	15°
LONG	45°

FIGURE I. PROJECTILE TRAJECTORY SHOWING VALUE OF INCIDENCE ANGLE (Ω) WITH RANGE

6 in. 53cal. GUN
TRAJECTORIES
I.V. = 3000 F.S.
105 LB. M.C. PROJECTILE
NAVY DEPARTMENT
BUREAU OF ORDNANCE

a. Short Range

$\frac{1}{2}$ Sin (Theta) + w Cos (Theta)

b. Medium Range

1 Sin (Theta) + Cos (Theta) [w = 1 Sin (Omega)]

c. Long Range

1 Sin (Theta) + Cos (Theta) [w + 1 Sin (Omega)]

Where:

Omega = Incidence Angle

Theta = Target Angle

1 = Target Length

w = Target Width

The values taken for Theta are 0, 15, 30, 45, 60, 75, 90 degrees.

Once the computations were completed and the values normalized, a matrix of target aspect factors was constructed as it is shown below in Table 1.

TABLE 1: Target Aspect Factors

	0	15	30	45	60	75	90
Short	.22	.47	.69	.86	.90	1.02	1
Medium	.37	.61	.82	.96	1.05	1.06	1
Long	.80	1.04	1.20	1.28	1.27	1.17	1

The above matrix shows the target factors values per range and per target angle. The reason for their behavior is because gunnery errors in range and deflection can usually be described by a normal distribution which is also represented by two parameters, Mean Error (ME) and Probably Error (PW). In the absence of bias, Mean Error is equal to Probable Error (ME=PE). In this case, then, the distribution of the errors is circular and the ME and PE are called Circular Error Probable (CEP). But in our case bias is present due to the delivery error of guns in the system and the distribution is Elliptical Normal with the deflection error smaller than range error. The result is that at long range when omega is greatest the target aspect factor is much less than at short range when the gunfire is nearly horizontal. That is the reason why the Target Aspect Factor decreases in relativity as the range increases.

2. <u>Hit Probability as a Function of Range</u>

Once again due to non-availability of real data, it was necessary to find a rational way to obtain numerical values which represent how accurate the weapons systems are and how they are affected by the range. Assuming that the probability of impact of the weapons decreases as the range increases, a graphical relationship was developed in order to have a source that would vary the values of hit probability with respect to range. For doing this two gun types were chosen (5 inch and 4.5 inch); see Figures 2 and 3.

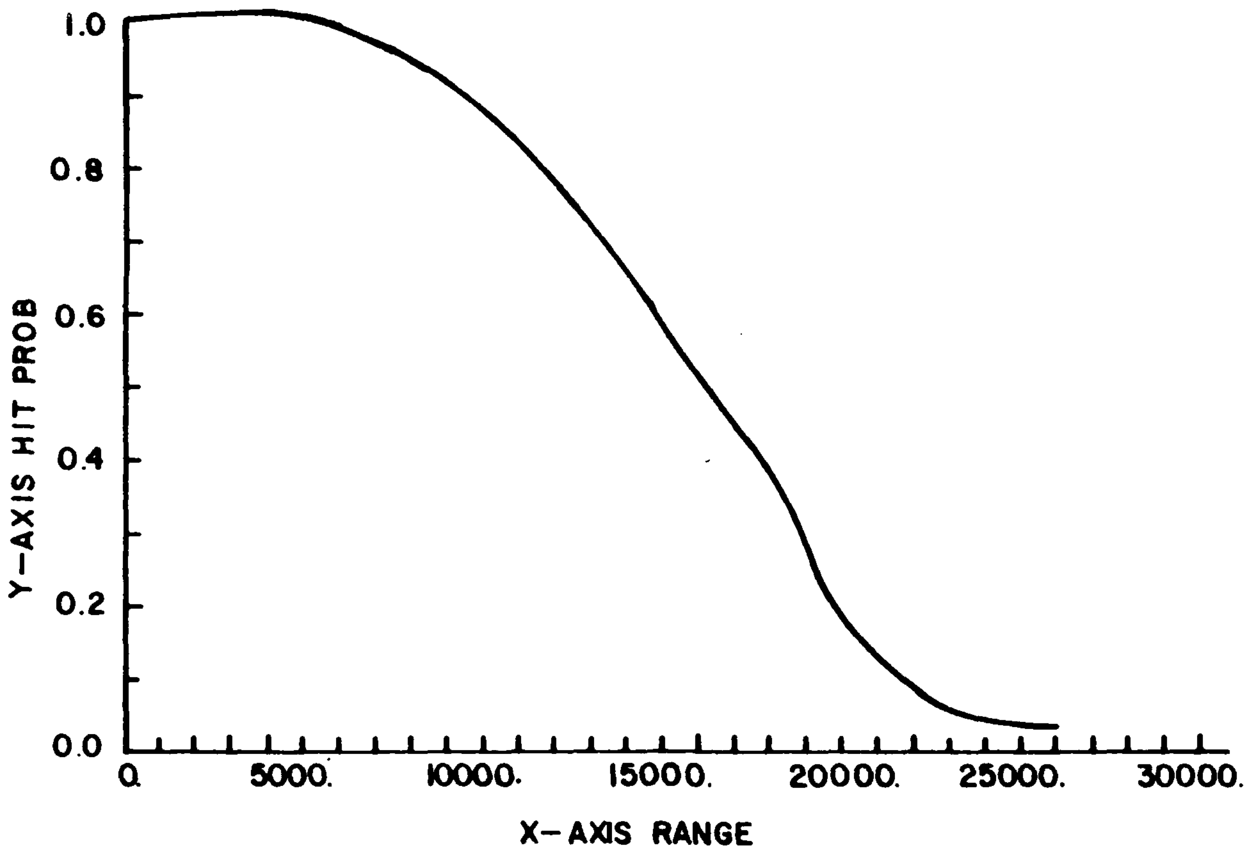


Figure 2. Graphical Representation of Hit Probabilities as a Function of Range for Gunfire (Blue)

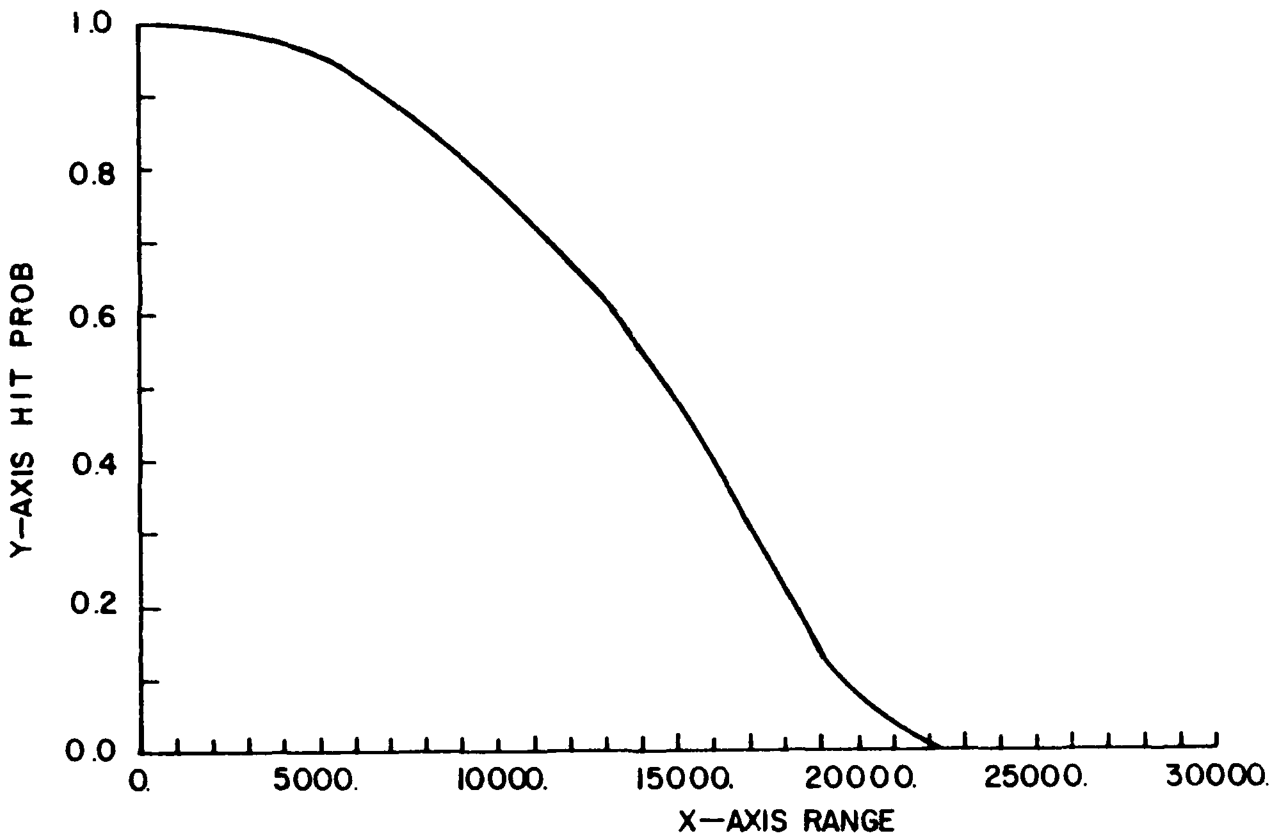


Figure 3. Graphical Representation of Hit Probabilities as a Function of Range for Gunfire (Red)

3. Expected Damage Given A Hit

For this a relationship was developed such that as the size of the target increases the expected damage due to critical hits will decrease. In other words, the degree of target vulnerability is inversely proportional to the target size. See Figure 4 and Figure 5 for Blue and Red, respectively.

4. Sea State

The sea condition is a well known factor which degrades the effectiveness and accuracy of the gunfire, where the personal capabilities and the stabilizations systems are down graded enough to considerably reduce the overall effectiveness of the system. The scale was used as a reference point to build a factor table which would have an equivalent factor for each Beaufort state. For values equivalent to Beaufort Scale 5 or above, the effectiveness of surface forces engagement are highly diminished. See Table 2.

5. Deceptive Jamming Factor

Deceptive jammers interfere with enemy gunfire control, the guidance of the missile weapons, and their acquisition systems. The effect of deceptive jammers is to increase the probable error and also to deflect the aimpoint back behind the center of the target with the results that the hit probability decreases. For the purpose of the model when deceptive jamming is being employed, a random

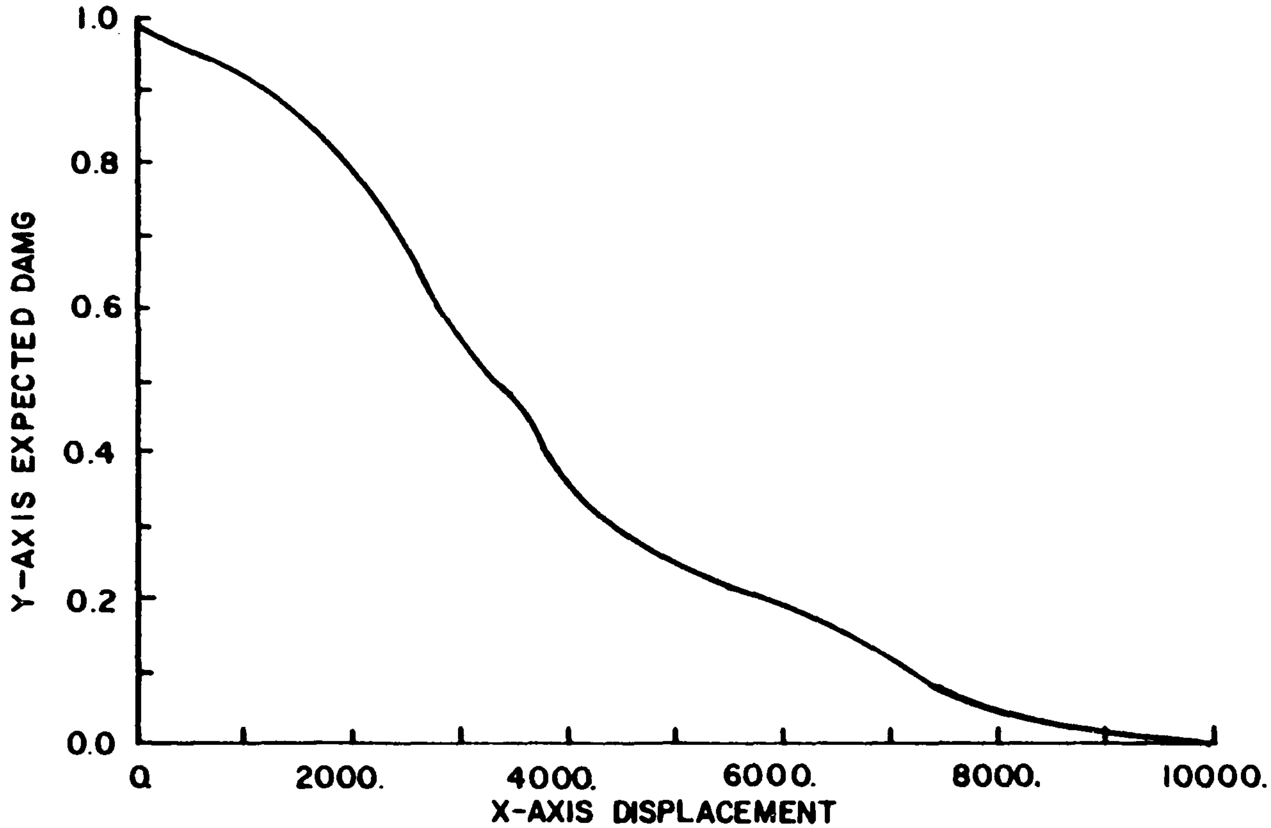


Figure 4. Expected Damage vs Range for Gunfire (Blue)

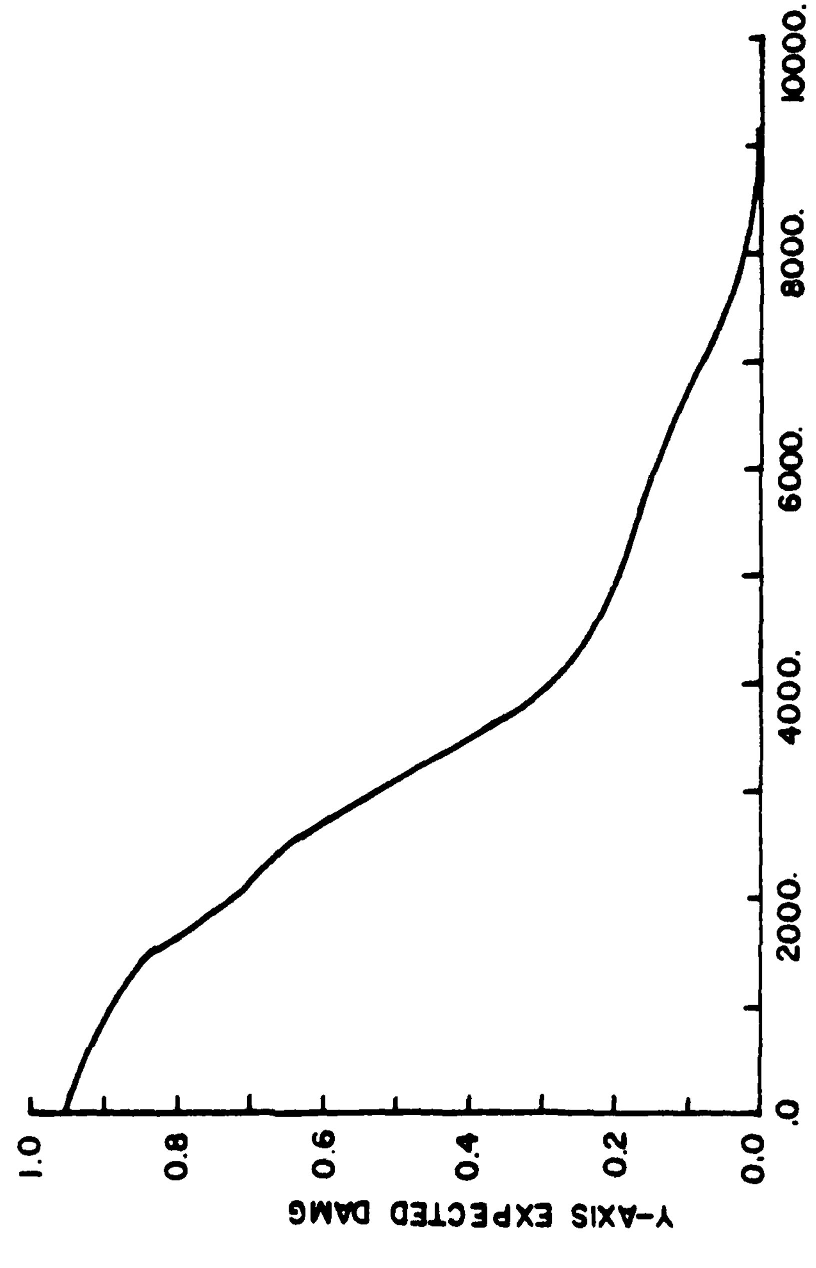


Figure 5. Expected Damage vs Range for Gunfire (Red)

TABLE 2. Beaufort Scale and Equivalent Sea State Factor

Beaufort	Sea State Factor
0&1	1.0
2	.8
3	.7
4	.7
5	.6
6	.5
7	.4
8	.4
9	.3
10	.3
11	.2
12	.1

Aircraft Carriers and Battleships.

Total Life (slife) = Displacement/100

Carriers.

Total Life (slife) = Displacement/70

Destroyers and Frigates

Total Life (slife) = Displacement/30

Corvetes and below.

number is chosen between .5 and 1.0. This value represents in the model a reduction in the weapons effectiveness which goes from a maximum effect of .5 to a minimum effect of 0. There is no consideration of multiple deceptive jammers in the model.

6. Rate of Fire

One of the questions which varies with operational circumstances is, what rate of fire should be used? This factor depends upon the tactical situation, state of training, enemy characteristics, magazine capacity, etc.; but the rate of fire must be consistent with the individual ships' circumstances, and will often not be as much as the theoretical, or gunnery range maximum.

In war games it is common that the players expect unrealistically high rates of fire, since the more rounds that are fired accurately during the action, the higher the cumulative kill probability is. When different firing rates are considered, fewer rounds expended at a high rate of accuracy may be more effective than more rounds expended at a lower rate of accuracy.

For this model in particular, the rate of fire that will be allowed is an input which has to be decided by the umpire, depending upon the tactical situation, state of training, and weapons reliability.

B. GUN FIRE DAMAGE CALCULATIONS

It was necessary to create a numerical value which represents the idea of life of the target. This value also represents in the model the target's capabilities to sustain damage; it will be reduced each time a hit occurs. For this purpose the displacement of the target in tons was considered to represent, in a way more or less tangible, the life of the ship along with a factor to use as a divisor in order to get what is believed to give a realistic relationship between hits and damage. This divisor changes for different targets or platforms. The total life value is derived in the following way:

Total Life (slife) = Displacement/20

The damage computations are conducted with the following steps:

1. For each interaction, a value of expected damage is obtained. It is called Expected Damage per Move. The value is computed by means of the following expression.

   EDMM = [Edam|Hit] * Ph * Rf * Seast * Xjamm * Tagta

   Where:

   EDMM = Expected Damage per Move.

   EDAM|hit = Expected Damage Given a Hit Occurs.

   PH = Hit Probability of the Weapon

   RT = Rate of Fire During the Engagement.

   Seast = Sea State

Xjamm = Deceptive Jamming.

Tagta = Target Aspect Factor.

2. The residual target life is computed applying the following linear expression.

$$RLIFE = RLIFE\ (1 - \sum_{L=1}^{m} EDMM)$$

3. The cumulative damage per move is simply the difference t life minus rlife.

CDPOINT = TLIFE - RLIFE

4. The percent floating capabilities is computed as follows.

FLOATC = (1 - CDPOINT/TLIFE) * 100

5. A coverage factor is required in order to establish how large the damage is to each ship's component along the target length.

SBAND = EDMM * TLENGTH

6. A location of where the target was hit was required and in order to do this the target length was considered as a base, ranging from zero (0) to five hundred (500), then a uniform random number was drawn. The number gives the physical location of the weapon hit on the target.

Once the hit place is determined, the next step is to find out which of the systems on board were knocked out or damaged. The hit place is considered the center. The upper bound of the hit will be the hit place plus half of the coverage factor, and the lower bound will be the hit place minus half of the coverage factor.

$$\text{DAMAGE AREA} = (\text{sband}/2 \leq \text{hplace} \leq \text{sband}/2)$$

An example of how hit placement, coverage factor, and target elements are determined is shown in Figure 6. Figure 6 is a sketch of a target type showing the target elements subject to suffering an amount of damage per move or during the engagement.

Line "A" shows where the target elements are placed along the target length from stern to bow.

Line "B" shows where the hit has occurred and how many target elements were subject to damage.

Let's suppose that the outcome of a uniform random number is 250. This number indicates that the place where the hit occurred was at 250' from stern to bow. The area of the ship suffering damage is given by the size of the Coverage Factor (SBAND) whose center is placed at hit place (HP). This physical dimension equals to SBAND/2 (250 ± 50).

The actual target elements which suffer damage are those which are located within the area between 200' and 300'. For this particular example they are:

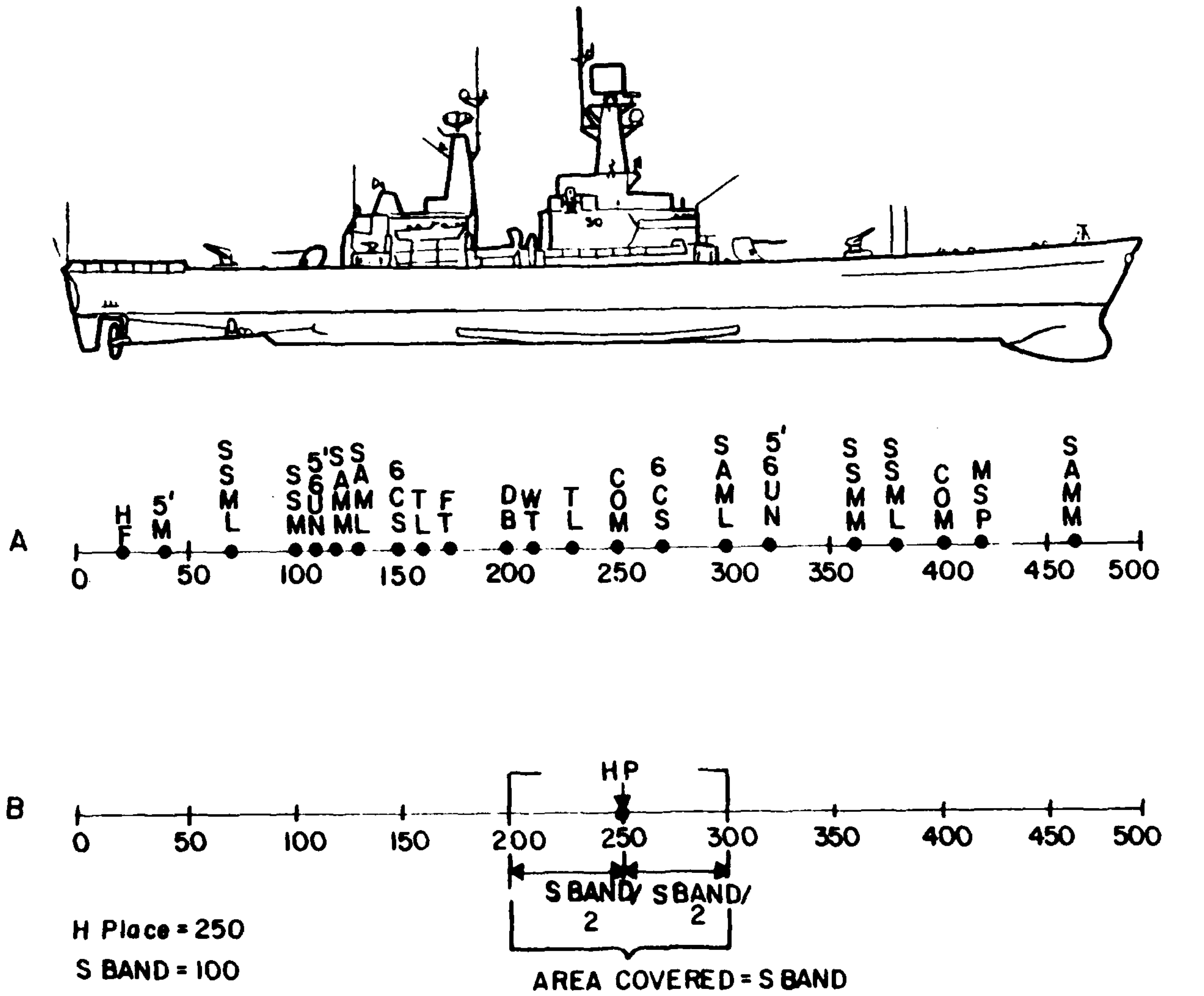


Figure 6. Graphical Representation of Target Placement (A) and Covered Area (B)

DAMAGE BRIGADE I

WATER TANK

TORPEDO LAUNCHER II

COMMUNICATION SYSTEMS (UHF-HF)

5" GUN CONTROL SYSTEM II

SURFACE-AIR MISSILE LAUNCHER II

A first step before the start of the game is to locate the target elements as they are actually positioned along the target length. Each element is given an initial condition, a location on the target, an identification number, and, the degradation factor. The degradation factor indicates the percent of damage each target element suffers if it is hit; the amount of damage is cumulative per move. There are twenty-two target elements in the sample table shown below, Table 3.

Table 3 was used for a Red Target; one similar for Blue, but with different distribution elements and different factors was also designed.

After each move the players and the game director will have available a computer output showing the residual capability values of all the target's elements. These will be the input for the next move. Also a summary, called History, will be available with all the computations done during the game.

TABLE 3. Target Elements Distribution

Target Element	Target Ident.	Target Place	Target Condition	Target Damage Factor
HELO FUEL	1	10	28000 gals.	.25
5' MAGAZINE	2	40	100%	.50
SSML I	3	70	100%	.50
SSM MAGAZINE	4	100	4	.50
5' GUNd	5	110	100%	.50
SAM MAGAZINE	6	120	9	.50
SAML I	7	130	100%	.50
GUN C SYSTEM	8	150	100%	.50
TORPEDO L I	9	160	100%	.50
FUEL TANK	10	170	360 tons	.25
DAMGE BRIG. I	11	200	100%	.50
WATER TANK	12	210	20000 gals.	.25
TORPEDO L II	13	230	100%	.50
COM. HF UHF	14	250	100%	.50
GUN C SYSTEM II	15	270	100%	.50
SAML II	16	300	100%	.50
5' GUN	17	320	100%	.50
SSM MAGAZINE	18	360	4	.50
SSM L II	19	380	100%	.50
COM LF VHF	20	400	100%	.50
MAX SPEED	21	420	38K	.25
SAM MAGAZINE	22	460	9	.50

The damage to certain ship elements like Surface Radar, Electronic Countermeasures (passive and active), Air Radar, and the Helo, considered separately as a kill-no-kill calculation.

C. MISSILE DAMAGE MODEL

The missile damage model basically follows the same structure as the gun fire model with slight differences in the factors under consideration. The factors considered are:

a. Expected Damage per Missile Hit as a Function of Target Size.

b. Missile Hit Probability as a Function of Range.

c. Target Aspect.

d. Sea State.

e. Number of Missile Impacts.

f. Warhead Factor.

These will be considered in more detail as follows.

1. Expected Damage Given a Missile Hit (range)

As in the Gun Fire case, a set of values assuming a relationship between the range and the damage due to critical hits was developed from hypothetical data.

In Figure 7 this relationship is presented graphically showing how the damage due to critical hits decreases as the target size increases. One of these graphs was created for both Blue and Red forces.

2. Missile Hit Probability as Function of Range

This is similar to the way it was treated for the Gun Fire case. It's graphical consideration is shown in Figure 8.

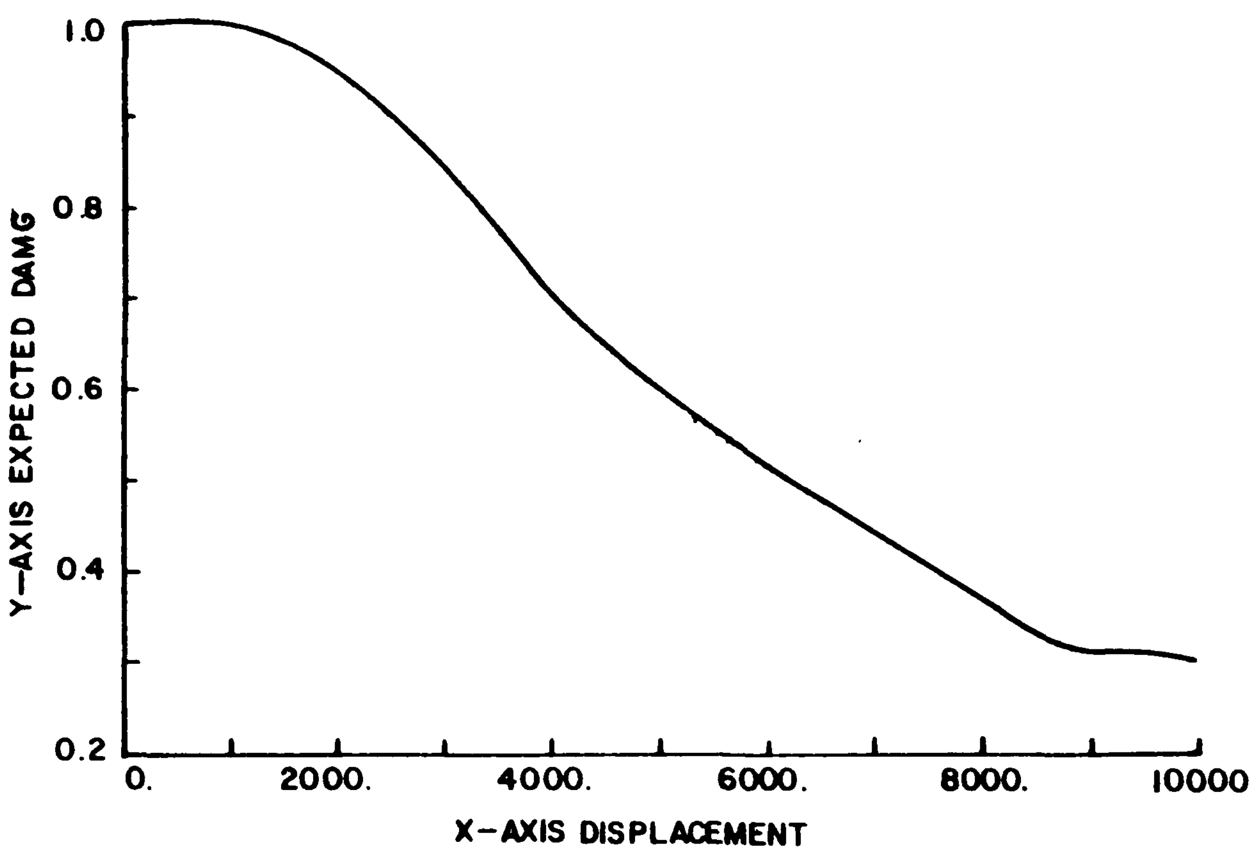


Figure 7. Expected Damage vs Range for Missile Fire (Blue & Red)

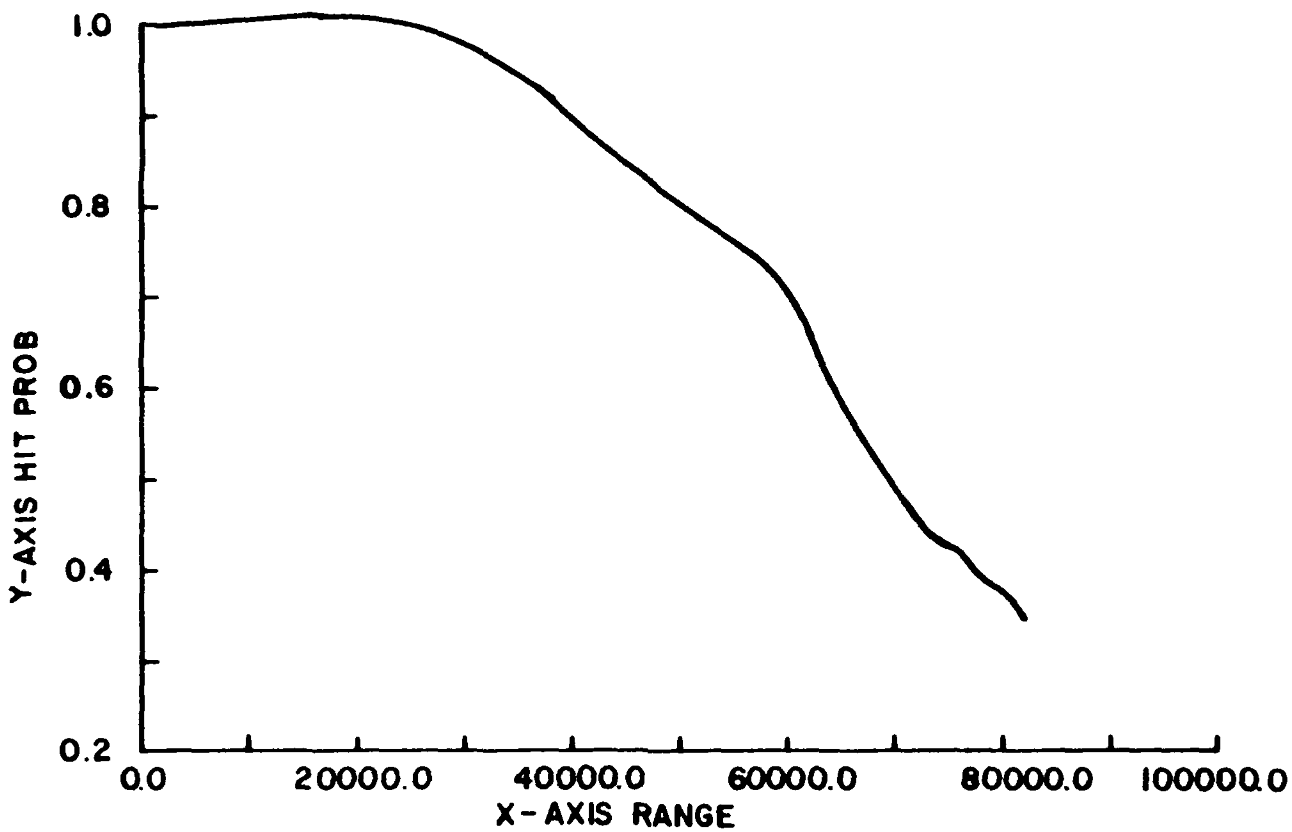


Figure 8. Graphical Representation of Hit Probabilities as a Function of Range for VMissile Fire (Blue & Red)

3. Target Aspect Factor

The missile model included the target aspect factor with a constant value equal to one (1). This is presented in this simple form because it will require further analysis which should be considered later as an improvement for the model.

4. Deceptive Jamming

This factor is considered in the same way it was for the Gun Fire case.

5. Missile Impacts

This factor was included as a multiplicative factor depending on the number of missiles remaining alive after considering the defense capabilities of the target ship. It was thought that a single target is able to shoot down the first incoming missile with probability equal to 0.7 and shoot down a second incoming missile with probability of 0.25. Using the technique of drawing a random number and comparing it with the above probabilities, we assess how many of the detected missiles constitute a surviving threat to the target ship.

Once we know the remaining missiles alive, we again pull a random number. By comparing it with the missile kill probability (0.7), we establish how many of them make impact on the target.

6. Warhead Weight Factor

Knowing that the destructive power of a missile mainly depends on the explosive charge it carries, the inclusion of this aspect was considered of great importance.

This factor was obtained as a ratio between the actual missile warhead weight and a warhead weight type. In this case, the weight of 250 pounds was taken as standard. This value is fed into the general expression to calculate the ccumulative damage.

WHEAD = MISSILE WARHEAD WEIGHT / 250

Where:

WHEAD = Warhead Factor

D. MISSILE DAMAGE CALCULATIONS

For missile damage calculations the following expression was used in order to compute the Expected Damage per Move:

EDMM = (EMHIT)*PHIT*IMPAT*XJAMM*WHEAD*SEAST*TAGTA

Where:

EDMM = Expected Damage per Move

EMHIT = Expected Damage per Missile Hit

PHIT = Missile Hit Probability

IMPAT = Missile Impacts on Target

XJAMM = Deceptive Jamming Factor

WHEAD = Warhead Weight Factor

TAGTA = Target Aspect Factor

SEAST = Sea State

After the expected damage per move has been computed, the rest of damage calculations are the same as in the gunfire model.

III. PROGRAM DESCRIPTION

A computer program was written to support the model. The present chapter will explain in detail how it was used and how the data was handled. The listing of the computer program is presented in Appendix A.

The program is suitable to assess damage for any number of targets (in the example N = 4), one at a time in two versions, Gun Fire and Missile Fire.

A. INPUT

Two sets of data were used for each force, independently, and were called Blue Data1, Blue Data2, Red Data1, and Red Data2. Those sets of data are shown in the appendix. They contain the following information in the order they appear.

1. Data1

NAME OF THE SHIP	NS
TARGET RANGE	KRANGE
TARGET LENGTH	TARLE
TARGET WIDTH	TARWI
TARGET DISPLACEMENT	TONS
TARGET ANGLE	THETA
DEFENSE FACTOR	DIFAC
SEA STATE	SEAST
RATE OF FIRE	SRT

MISSILE HIT PROB.	ZPHIT
MISSILE WARHEAD WEIGHT	HWEIT
GUNFIRE RANGE	R1
MISSILE FIRE RANGE	R2
MAXIMUM GUN FIRE RANGE	MRANGE
DISPLACEMENT	DISP
EXPECTED DAMAGE/HIT	EDMH
TARGET RANGE	TAR
GUN HIT PROBS.	YHIT
SHORT RANGE TAGTA FACTOR	sFAC
MEDIUM RANGE TAGTA FACTOR	mFAC
LONG RANGE TAGTA FACTOR	ZFAC
TARGET ELEMENT IDENTIFICATION	IDENT
TARGET ELEMENT PLACE	TPLACE
TARGET ELEMENT DEGRATING FACTOR	TEFAC

2. <u>Data2</u>

TARGET ELEMENT CONDITION	TCOND
TOTAL LIFE	SLIFE
REMAINING LIFE	RLIFE
CCUMULATIVE DAMAGE	SUM
HIT PLACE	HPLACE
GAME TIME	GTIME
SEEDS	IX,IX1,IX2,IX3,IX4

B. PROGRAM RUN

The program is fed with Datal and Data2 per side each time we want to establish the amount of damage sustained for a target after a move has occurred. This procedure is to be done for each target separately. For the subsequent moves it is necessary to introduce the changes required by the new tactical conditions and with the prior damage results.

C. PROGRAM OUTPUT

The outcome of each engagement will consist of two printed outputs which will be stored in files called History1 and History2 for each side, and will be a compilation of the moves. In order to identify to which side the file corresponds, a letter B (blue) or R (red) will be placed before the word history.

1. HISTORY1 File

This file will contain the following information:

Type of Engagement (Gun or Missile Fire)

Target Name

Number of Missiles Detected

Number of Missiles Shotdown

Number of Missiles Alive

Number of Missile Impacts on Target

Target Aspect Factor

Expected Damage per Move

Remaining Life

Cumulative Damage

Floating Capabilities

Total Life

Hit Probability (Gun or Missile) of Engagement

Hit Place

Deceptive Jamming Factor

Coverage Factor

Target Elements Hit in the Move

Residual Conditions of all Target Elements

2. HISTORY2 File

This file will contain the information concerned with the residual conditions of the targets considered in the game. This information will become the initial conditions for subsequent moves.

IV. RESULTS AND FUTURE IMPROVEMENTS

A. RESULTS

The objective of the model, namely to obtain more rapid, accurate and realistic results during the damage assessment process, has been achieved. By giving the results to the game director and to each player, more time will be gained for tactical decisions and play. As reliable, validated inputs are provided, the model will present realistic combat outcomes to assist in the development of improved tactical doctrine.

B. FUTURE IMPROVEMENTS

The present model was developed as a tool for war gaming damage assessment that provided accuracy, realism, and rapid computations during the conduct of the game.

Future improvements should include the following:

1. Validation

   The model was developed and tested to a great extent with hypothetical data due to the absence of real or experimental data. Such data should be acquired to confirm or improve the model's accuracy and reliability.

2. Tactical Improvements

a. The model now only considers a surface naval engagement involving Gun and Missile fire. The expansion of the model to include other important aspects, such as the ASW Warfare, AAW Warfare, Torpedo Attack, and Mines will enhance the utility of the model.

b. The expansion of the model by including the possibility of treating more than one platform at the same time will accelerate the Damage Assessment process.

c. The consideration of the target aspect factor in a missile engagement is an important future refinement for accuracy, and in addition will show how this factor affects the outcome of the engagement.

d. The inclusion of the effects of damage to the Command Control and Communications will introduce in the game a factor of vital importance which is often overlooked during the conduct of fleet exercises and war games.

APPENDIX A

This appendix contains a list of variables in the order they appear in the program, a listing of the program, and inputs for force blue and red.

LIST OF VARIABLES

SLIFE	TARGET TOTAL LIFE
TONS	TARGET DISPLACEMENT
XJAMM	DECEPTIVE JAMMING FACTOR
KRANGE	DETECTION RANGE
THETA	TARGET ASPECT ANGLE
MRANGE	MAXIMUM RANGE
TAGTA	TARGET ASPECT
SFAC	SHORT RANGE TARGET ASPECT FACTOR
TFAC	MEDIUM RANGE TARGET ASPECT FACTOR
ZFAC	LONG RANGE TARGET ASPECT FACTOR
DISPR	DISPLACEMEMTS TYPE
FEDHR	EXPECTED DAMAGE AS FUNCTION OF TARGET SIZE (GUN)
JRGED	TARGET RANGE
SRF	RATE OF GUN FIRE
SEAST	SEA STATE
PHIT	GUN HIT PROBABILITY
NS	TARGET NAME
NM	NUMBER OF MISSILES DETECTED

PK1M	PROBABILITY OF KILL FIRST INCOMING MISSILE
PK2M	PROBABILITY OF KILL SECOND INCOMING MISSILE
DIFAC	TARGET ANTI-MISSILE DEFENSE FACTOR
SDC	TARGET ANTI-MISSILE DEFENSE CAPABILITY
MALIVE	NUMBER OF MISSILES ALIVE
IMPAT	NUMBER OF MISSILE IMPATS ON TARGET
WHEAD	MISSILE WARHEAD WEIGHT FACTOR
HWEIT	MISSILE WARHEAD WEIGHT
EMHIT	EXPECTED DAMAGE PER MISSILE HIT
SBAND	COVERED AREA
PHB	HIT PROBABILITY AS FUNCTION OF RANGE (GUN)
TARLE	TARGET LENGTH
CDMPO	CCUMULATIVE DAMAGE PER MOVE
RLIVE	TARGET REMAINING LIFE
FLCAP	TARGET FLOATING CAPABILITIES
HPLACE	HIT PLACE
HALF	HALF COVERED AREA
UHALF	UPPER BOUND COVERED AREA
THALF	LOWER BOUND COVERED AREA
HLPK	HELO DAMAGE PROBABILITY
PCPK	ECM DAMAGE PROBABILITY
SRPK	SURFACE RADAR DAMAGE PROBABILITY
ARPK	AIR RADAR DAMAGE PROBABILITY
ACPK	ECCM DAMAGE PROBABILITY

```
C*********************************************************************
C**                                                                 **
C** COMPUTER PROGRAM OF A DAMAGE ASSESSMENT MODEL  OF  A SURFACE EN  **
C**                                                                 **
C** GAGEMENT BETWEEN TWO FORCES (RED & BLUE ) WITH MISSILE AND GUNFIRE**
C**                                                                 **
C**         *  BY COMMANDER  MARIO IVAN CARRATU MOLINA  *            **
C**                                                                 **
C**              " ARMADA REPUBLICA DE VENEZUELA "                  **
C**                                                                 **
C**               * NAVAL POSTGRADUATE  SCHOOL *                    **
C**                                                                 **
C**         MONTEREY,CALIFORNIA   ********      MARZO  1982         **
C*********************************************************************
        COMMON   EDHR(25),DISPR(25),SFAC(10),TFAC(10),ZFAC(10),KRNGE,
     THETA ,MRNGE,TAGTA,SEAST,PHB(25),JRGEB(25),PHR(25),JRGER(25),
     EDHB(25),DISPB(25),TCOND(4,22),IDENT(4,22),TPLACE(4,22),
     TARLE,TARWI,SRF,RLIFE,R1,R2,ZPHIT,DISP(25),EDMH(25),IX,IX1,IX2,
     TAR(25),YHIT(25),RT2(12),IX3,DIFAC,NM,WHEAD,HPLACE,SDC(20),IX4,
     RT1(20),GTIME,RT3,HWEIT,TEFAC(4,22),NS
C
C     MODEL INPUT DATA
C
        NAMELIST/DATA1/KRNGE,TONS,EDHR,DISPR,SFAC,TFAC,ZFAC,MRNGE,THETA,
     SEAST,PHB,PHR,JRGER,JRGEB,EDHB,DISPB,IDENT,TPLACE,TEFAC,TARLE,
     TARWI,SRF,R1,R2,ZPHIT,DISP,EDMH,TAR,YHIT,RT2,DIFAC,NM,WHEAD,
     HWEIT,NS
        NAMELIST/DATA2/ TCOND,SLIFE,RLIFE,SUM,HPLACE,GTIME,IX,IX1,
     IX2,IX3,IX4
        GTIME=0.
        KRNGE=0
        MRNGE=0
        DISP(I)=0.
        EDMH(I)=0.
        TAR(I)=0.
        YHIT(I)=0.
        DISPR(I)=0.
        TONS=0.
        THETA=0
        SUM=0.
        READ(5,DATA1)
        READ(4,DATA2)
        REWIND 4
C
C COMPUTATION OF DAMAGE CAPABILITY POINTS OF TARGET (LIFE)
C
```

```
      SLIFE= TONS/30                                                    FAK00480
C                                                                       FAK00490
C     GENERATION OF UNIFORM RANDOM DEVIATES IN ORDER TO HAVE RANDOMIZE FAK00500
C     JAMMING FACTOR.(UNIFORM FROM 0 TO 1.)                             FAK00510
C                                                                       FAK00520
      CALL LRND(IX,Y,N,1,0)                                             FAK00530
      XJAMM=.5*Y+.5                                                     FAK00540
      IF (KRNGE .LE. R1) GO TO 20                                       FAK00550
      GO TO 30                                                          FAK00560
   20 WRITE(6,11)                                                       FAK00570
   11 FORMAT(3X,' GUNFIRE ENGAGEMENT')                                  FAK00580
      WRITE(6,64)NS                                                     FAK00590
   64 FORMAT(3X,' TARGET NAME=',I4)                                     FAK00600
      K=6                                                               FAK00610
      DO 1 I=1,K                                                        FAK00620
      IF(THETA.GT.15*(I-1))GO TO 134                                   F
      GO  TO 40                                                         FAK00640
    1 CONTINUE                                                          FAK00650
   40 CONTINUE                                                          FAK00660
C                                                                       FAK00670
C     SCALING MAXIMUM RANGE BY CONSIDERING 30,60,90 PERCENT OF MAX RANGE FAK00680
C     AS SHORT,MEDIUM AND LONG RANGE RESPECTIVELY.                      FAK00690
C                                                                       FAK00700
C                                                                       FAK00710
      SHORT=MRNGE*.3                                                    FAK00720
      MDIUM=MRNGE*.6                                                    FAK00730
      LONG= MRNGE*.9                                                    FAK00740
C                                                                       FAK00750
C                                                                       FAK00760
C    SELECTION OF TARGET ASPECT FACTOR (ANGLE) AS  AFUCTION OF RANGE    FAK00770
C                                                                       FAK00780
C                                                                       FAK00790
      IF(KRNGE .LE.SHORT)GO TO 42                                       FAK00800
      IF(KRNGE .LE.MDIUM .AND.KRNGE.GT.SHORT)GO TO 50                   FAK00810
      IF(KRNGE .LE.MRNGE .AND.KRNGE.GT.MDIUM)GO TO 60                   FAK00820
      GO TO  80                                                         FAK00830
   42 TAGTA=SFAC(I)                                                     FAK00840
      GO TO 70                                                          FAK00850
   50 TAGTA=TFAC(I)                                                     FAK00860
      GO TO 70                                                          FAK00870
   60 TAGTA=ZFAC(I)                                                     FAK00880
      GO TO 70                                                          FAK00890
   70 WRITE(6,12)TAGTA                                                  FAK00900
C                                                                       FAK00910
C                                                                       FAK00920
C    COMPUTATION OF EXPECTED DAMAGE GIVEN A HIT PER WEAPON              FAK00930
C                                                                       FAK00940
```

```
C
   80 DO 2 I=1,20
      IF(TONS.LE.DISPR(I)) GO TO 3
    2 CONTINUE
    3 A=TONS -DISPR(I-1)
      B=DISPR(I)-DISPR(I-1)
      C=A/B
      A=EDHR(I)-EDHR(I-1)
      B=C*A
      FEDHR=EDHR(I-1)+B
C
C
C DETERMINATION OF HIT PROBABILITIES AS A FUCTION OF RANGE (5 INCHES)
C
C
      M=15
      DO 8 I=1,M
      IF(KRNGE.LE.JRGEB(I))GO TO 90
    8 CONTINUE
   90 AA=KRNGE - JRGEE(I-1)
      BB=JRGEB(I) - JRGEB(I-1)
      CC=AA/BB
      AA=PHB(I)-PHB(I-1)
      BB=CC*AA
      PHIT=PHB(I-1)+BB
      N=1
C
C
C  COMPUTATION OF EXPECTED DAMAGE PER MOVE GIVEN:RATE OF FIRE,HIT PROB
C  ABLITY,SEA STATE,EXPECTED DAMAGE GIVEN A HIT, JAMMING FACTOR,ANGLE
C  OF DE TARGET.
C
C
      EDMM=FEDHR*PHIT*SRF*SEAST*XJAMM*TAGTA
      GO TO 500
C
C
   30 IF (KRNGE .LE. R2) GO TO 100
      GO TO 1000
  100 WRITE(6,13)
   13 FORMAT(3X,' MISSILE ENGAGEMENT')
      WRITE(6,14)NS
   14 FORMAT(3X,' TARGET NAME=',I4)
C
C
C  COMPUTATION OF TARGET MISSILE DEFENSE CAPABILITIES
C
C
```

```
      K=0
      WRITE(6,15)NM
   15 FORMAT(3X,' NUMBER OF INCOMING MISSILES DETECTED=',I4)
      PK1M=.7
      PK2M=.25
      CALL SRND(IX1,ZZ,N,1,0)
      RT1(I)=ZZ
      SDC(I)=DIFAC*RT1(I)
      IF (SDC(I).LE.PK1M .AND. SDC(I).GT.PK2M) GO TO 110
      IF (SDC(I).LE.PK2M) GO TO 120
  110 K=K+1
      WRITE(6,16)K
   16 FORMAT (3X,' INCOMING MISSILE SHUTDOWN=',I4)
  120 K=K+1
      WRITE(6,17)K
   17 FORMAT (3X,' INCOMING MISSILE SHUTDOWN=',I4)
      IF (NM.LE.0) GO TO 1000
      GO TO 130
  130 MALIVE=NM-K
      WRITE(6,18)MALIVE
   18 FORMAT(3X,' NUMBER OF MISSILES  ALIVE=',I4)
      IF (MALIVE.GT.0) GO TO 140
      GO TO 1000
  140 IMPAT=0
      DO 5 I=1,MALIVE
      CALL SRND(IX2,YZ,N,1,0)
      RT2(I)=YZ
      IF (RT2(I) .GT. ZPHIT) GO TO 5
      IMPAT=IMPAT+1
    5 CONTINUE
      IF(IMPAT.GT.0) GO TO 150
      IMPAT=0
  150 WRITE(6,19)IMPAT
   19 FORMAT(3X,' NUMBER OF INPACTS ON TARGET=',I4)
C
C
C COMPUTATION OF EXPECTED DAMAGE AS FUNCTION OF TARGET SIZE
C
C
      DO 6 I=1,21
      IF(TONS.LE.DISP(I)) GO TO 160
    6 CONTINUE
  160 T=TONS-DISP(I-1)
      Q=DISP(I) - DISP(I-1)
      P=T/Q
      T=EDMH(I)-EDMH(I-1)
      Q=P*T
      EXPM=EDMH(I-1)+Q
```

```
      PHIT=EXPM                                                         PAK01910
C                                                                       PAK01920
C     COMPUTATION OF KILL PROBABILITIES AS A FUNCTION OF RANGE          PAK01930
C                                                                       PAK01940
      DO 7 I=1,21                                                       PAK01950
      IF(KRNGE.LE. TAR(I)) GO TO 170                                    PAK01960
    7 CONTINUE                                                          PAK01970
  170 TT=KRNGE- TAR(I-1)                                                PAK01980
      QQ=TAR(I)-TAR(I-1)                                                PAK01990
      PP=TT/QQ                                                          PAK02000
      TT=YHIT(I)-YHIT(I-1)                                              PAK02010
      QQ=PP*TT                                                          PAK02020
      EMHIT=YHIT(I-1)+QQ                                                PAK02030
C     FEDHR=EMHIT                                                       PAK02040
C                                                                       PAK02050
C                                                                       PAK02060
C     COMPUTATION OF DAMAGE PER MOVE AS A FCN OF EXPECTED DAMAGE PER    PAK02070
C     NUMBER OF MISSILE IMPACTS, WARHEAD JAMMING FACTOR,KILL PROBABILITYPAK02080
C                                                                       PAK02090
C                                                                       PAK02100
      WHEAD=HWEIT/250                                                   PAK02110
      TAGTA=1.                                                          PAK02120
      EDMM= EMHIT*PHIT*IMPAT*XJAMM*WHEAD*TAGTA*SEAST                    PAK02130
      FEDHR=EMHIT                                                       PAK02140
C                                                                       PAK02150
C COMPUTATION OF WEAPONS COVERAGE AREA ON THE TARGET                    PAK02160
C                                                                       PAK02170
  500 SBAND=EDMM*TARLE                                                  PAK02180
C                                                                       PAK02190
C COMPUTATION OF REMAINING TARGET LIFE AFTER EACH MOVE                  PAK02200
C                                                                       PAK02210
      SUM=EDMM+SUM                                                      PAK02220
      RLIFE=SLIFE*(1-( SUM))                                            PAK02230
C                                                                       PAK02240
C COMPUTATION OF CUMMULATIVE DAMAGE                                     PAK02250
C                                                                       PAK02260
      CDMPO=SLIFE-RLIFE                                                 PAK02270
C                                                                       PAK02280
C TARGET FLOATING CAPABILITIES  AFTER EACH MOVE                         PAK02290
                                                                        PAK02300
      FLCAP=(1-(CDMPO/SLIFE))*100
      IF(FLCAP .GT. 0.) GO TO 190                                       PAK02320
      GO TO  999                                                        PAK02330
C                                                                       PAK02340
C GENERATION OF UNIFORM RANDOM DEVIATES IN ORDER TO ASSET LOCATION OF   PAK02350
C WEAPON IMPACT UPON THE TARGET.                                        PAK02360
C                                                                       PAK02370
  190 CALL LRND(IX3,YY,N,1,0)                                           PAK02380
```

```
      HPLACE=500*YY                                                     FAK02390
C                                                                       FAK02400
C   DETERMINATION OF THE TARGET ELEMENTS WHICH WERE HIT OR ARE LOCATED  FAK02410
C   WHITIN IMPACT AREA.                                                 FAK02420
C                                                                       FAK02430
C                                                                       FAK02440
      HALF=SBAND/2                                                      FAK02450
      UHALF=HPLACE+HALF                                                 FAK02460
      THALF=HPLACE-HALF                                                 FAK02470
C                                                                       FAK02480
C                                                                       FAK02490
C    CALCULATIONS OF SENSORS KILL- NOT- KILL DAMAGE FOR AIR RADAR       FAK02500
C    SURFACE RADAR, ECM, ECCM,AND DAMAGE FOR HELO ON BOARD.             FAK02510
C                                                                       FAK02520
C                                                                       FAK02530
      HLPK=.8                                                           FAK02540
      PCPK=.7                                                           FAK02550
      SRPK=.5                                                           FAK02560
      ARPK=.4                                                           FAK02570
      ACPK=.2                                                           FAK02580
      CALL LRND(IX4,X,N,1,0)                                            FAK02590
      SES=YYY                                                           FAK02600
      IF(SES .GT. 0.  .AND.SES .LE. ACPK) GO TO 51                      FAK02610
      IF(SES .GT. ACPK .AND. SES .LE. ARPK) GO TO 61                    FAK02620
      IF(SES .GT. ARPK .AND. SES .LE. SRPK) GO TO 71                    FAK02630
      IF(SES .GT. SRPK .AND. SES .LE. PCPK) GO TO 81                    FAK02640
      IF(SES .GT. PCPK .AND. SES .LE. HLPK) GO TO 91                    FAK02650
      IF(SES .GT. HLPK) GO TO 999                                       FAK02660
   51 WRITE(6,31)                                                       FAK02670
      GO TO 999                                                         FAK02680
   61 WRITE(6,32)                                                       FAK02690
      GO TO 999                                                         FAK02700
   71 WRITE(6,33)                                                       FAK02710
      GO TO 999                                                         FAK02720
   81 WRITE(6,34)                                                       FAK02730
      GO TO 999                                                         FAK02740
   91 WRITE(6,35)                                                       FAK02750
  999 J=22                                                              FAK02760
C                                                                       FAK02770
C   DETERMINATION OF DAMAGE DEGRADATION OF TARGET ELEMENTS BY TAKING    FAK02780
C   IN CONSIDERATION THEIR INDIVIDUALS DAMAGE FACTORS.                  FAK02790
C                                                                       FAK02800
C                                                                       FAK02810
      WRITE(6,22)                                                       FAK02820
   22 FORMAT(3X,' DAMAGE RESUMEN ')                                     FAK02830
      WRITE(6,23) FEDHR,EDMM,RLIFE,CDMPO,FLCAP,SLIFE,PHIT,HPLACE,XJAMM, FAK02840
     SBAND                                                              FAK02850
      WRITE(6,24)                                                       FAK02860
```

```
   24 FORMAT(//,5X,' TARGET ELEMENTS WHICH WERE DAMAGE DURING THE MOVE    FAK02870
     ',//)                                                               FAK02880
      WRITE(6,25)                                                        FAK02890
   25 FORMAT(5X,' TARIDENT',5X 'TARPLACE',5X,' TARCOND',)                FAK02900
                                                                        FAK02910
      DO 10 I=1,J                                                        FAK02920
      IF(TPLACE(NS,I).LT.THALF .OR. TPLACE(NS,I).GT. UHALF) GO TO 10     FAK02930
      GO TO 210                                                          FAK02940
  210 TCOND(NS,I)=TCOND(NS,I) - TEFAC(NS,I)*TCOND(NS,I)                  FAK02950
      IF(TCOND(NS,I) .LT. 0.) TCOND(NS,I)=0.                             FAK02960
      WRITE(6,26)IDENT(NS,I),TPLACE(NS,I),TCOND(NS,I)                    FAK02970
   10 CONTINUE                                                           FAK02980
      WRITE(6,27)                                                        FAK02990
      WRITE(6,28)                                                        FAK03000
   27 FORMAT(//,5X,' SURVIVAL CONDITION OF ALL TARGET ELEMENTS AFTER MOVFAK03010
     E',//)                                                              FAK03020
   28 FORMAT(5X,' TARIDENT',5X 'TARCONDE',5X,'TARFACTOR',5X,'TARPLACE')  FAK03030
      WRITE(6,29)(IDENT(NS,I),TCOND(NS,I),TEFAC(NS,I),TPLACE(NS,I),I=1   FAK03040
     ,J)                                                                 FAK03050
C  25 FORMAT(3X, ' RANGE BIGGER THAN DETECTION RANGE')                   FAK03060
   12 FORMAT(3X, ' TARGET ASPECT=',F8.3)                                 FAK03070
   29 FORMAT(/,6X,I4,9X,F8.1,4X,F8.3,4X,F8.1,/)                          FAK03080
   26 FORMAT(/,6X,I4,9X,F8.1,7X,F8.2,/)                                  FAK03090
   23 FORMAT(3X,' EXPECTED DAMAGE|HIT=',F8.3,/,4X,'EXPECTED DMAGE PER    FAK03100
     MOVE=',F8.3,/,4X,'RMAINING LIFE=',F8.3,/,4X,'CUMM DAMGE=',F8.3,/    FAK03110
     ,4X,'FLOATING CAP=',F8.3,/,3X,' TTAL LIFE=',F8.3,/,3X,' HIT PROBAB  FAK03120
     ILITY=',F8.3,/,3X,' HIT PLACE=',F8.3,/,3X,' JAMMING FACTOR=',F8.3   FAK03130
     ,/,3X,' COVERAGE FACTOR=',F8.3,/)                                   FAK03140
   31 FORMAT(3X,' ACTIVE COUNTERMEASURES CAPABILITIES LOST' )            FAK03150
   32 FORMAT(3X,' AIR DETECTION CAPABILITIES LOST')                      FAK03160
   33 FORMAT(3X,' SURFACE DETECTIONCAPABILITIES LOST')                   FAK03170
   34 FORMAT(3X,' PASIVE COUNTERMEASURES CAPABILITIES LOST')             FAK03180
   35 FORMAT(3X,' HELICOPTER DESTROYED')                                 FAK03190
      GTIME=GTIME+3                                                      FAK03200
C1000 WRITE(6,206)                                                        FAK03210
C 206 FORMAT(3X,' NO AIRBORNE MISSILE AT THE MOMENT')                     FAK03220
 1000 WRITE(4,DATA2)                                                     FAK03230
      STOP                                                               FAK0324
      END                                                                FAK033a
C
C  BLUE DATA ONE
C
&DATA1
NS=4,
KRNGE=39678,
TARLE=500.,
TARWI=55.,
TONS=5643.,
```

```
 THETA= 68.,
 DIFAC=.7,
 SEAST=.5,
 SRF=8,
 NN=3,
 ZPHIT=.7,
 HWEIT=250.,
 R1=26000.,
 R2=800000.,
 MRNGE=26000,
 DISP=0.,500.,1000.,1500.,2000.,2400.,3000.,3500.,4000.,4500.,5000.,
5500.,6000.,6500.,7000.,7500.,8000.,8500.,9000.,9500.,10000.,
 EDMH=1.0,1.0,1.0,.98,.97,.91,.84,.78,.70,.63,.60,.55,.50,.48,.44,
.40,.37,.33,.31,.31,.30,
 TAR=0,5000,10000,15000,20000,25000,30000,35000,40000,45000,50000,
55000,60000,65000,70000,72000,74000,76000,78000,80000,82000,
 YHIT=1.0,1.0,1.0,1.0,1.0,1.0,.98,.95,.88,.85,.82,.78,.70,.58,.49,
.45,.43,.42,.39,.38,.35,
 EDHR=1.,.95,.92,.87,.80,.72,.53,.48,.35,.30,.25,.21,.19,.15,.12,.07,
.05,.02,.01,.007,.003,
 DISPR=0.,500.,1000.,1500.,2000.,2400.,3000.,3500.,4000.,4500.,5000.,
5500.,6000.,6500.,7000.,7500.,8000.,8500.,9000.,9500.,10000.,
 PHB=1.,1.,1.,1.,1.,1.,.97,.92,.88,.83,.78,.69,.59,.51,.45,.40,.30,
.18,.10,.05,.03,
 JRGEB=1000,2000,3000,4000,5000,6000,7000,9000,10000,12000,13000,
14000,15000,16000,17000,18000,19000,20000,22000,23000,26000,
 SFAC=.22,.47,.69,.86,.90,1.02,1.0,30.,
 TFAC=.37,.61,.82,.96,1.05,1.06,1.0,30.,
 ZFAC=.8,1.04,1.20,1.28,1.27,1.17,1.0,36.,
 IDENT=1,1,1,1,2,2,2,2,3,3,3,3,4,4,4,4,5,5,5,5,6,6,6,6,7,7,7,7,8,8,8,8,
9,9,9,9,10,10,10,10,11,11,11,11,12,12,12,12,13,13,13,13,14,14,14,14,
15,15,15,15,16,16,16,16,17,17,17,17,18,18,18,18,19,19,19,19,20,20,20,
20,21,21,21,21,22,22,22,22,
 TEFAC=.25,.25,.25,.25,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,
.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.25,.25,.25,.25,.5,.5,
.5,.5,.25,.25,.25,.25,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,
.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.25,.25,.25,.25,.5,.5,
.5,.5,
 TPLACE=10,10,10,10,40,40,40,40,70,70,70,70,100,100,100,100,110,110,
110,110,120,120,120,120,130,130,130,130,150,150,150,150,160,160,160,
160,170,170,170,170,200,200,200,200,210,210,210,210,230,230,230,230,
250,250,250,250,270,270,270,270,300,300,300,300,320,320,320,320,360,
360,360,360,380,380,380,380,400,400,400,400,420,420,420,420,460,460,
460,460,
 &END
C
C BLUE DATA TWO
C
```

```
 &DATA2
 TCOND=28000,30000,26000,19000,100,100,100,100,100,100,100,100,4,6,4,3,
100,100,90,90,9,8,6,6,100,100,100,100,100,90,90,95,100,100,100,100,
360,290,300,298,100,100,100,100,20000,20000,28000,22000,100,100,100,
100,100,90,80,70,100,100,100,100,100,100,100,100,100,100,90,90,4,6,4,
3,100,100,100,100,100,100,80,95,38,36,30,32,9,8,6,6,
 GTIME=0.,
 SUM=0,
 IX=45,
 IX1=99,
 IX2=80,
 IX3=545,
 IX4=742,
 &END
C
C RED DATA ONE
C
 &DATA1
 NS=2,
 KRNGE=48000,
 TARLE=500.,
 TARWI=55.,
 TONS=5643.,
 THETA=120.,
 DIPAC=.7,
 SEAST=.7,
 SRF=9,
 NM=5,
 ZPHIT=.7,
 HWEIT=250.,
 R1=26000.,
 R2=800000.,
 MRNGE=22000,
 EDHR=1.,.95,.92,.87,.83,.72,.65,.52,.40,.28,.23,.20,.17,.15,.11,.08,
.04,.03,.01,.007,.003,
 DISPR=0.,500.,1000.,1500.,2000.,2400.,3000.,3500.,4000.,4500.,5000.,
5500.,6000.,6500.,7000.,7500.,8000.,8500.,9000.,9500.,10000.,
 PHB=1.,1.,1.,1.,.95,.88,.81,.76,.71,.67,.61,.55,.48,.40,.31,.25,.12,
.08,.01,.00,.00,
 JRGEB=1000,2000,3000,4000,5000,6000,7000,9000,10000,12000,13000,
14000,15000,16000,17000,18000,19000,20000,22000,23000,26000,
 DISP=0.,500.,1000.,1500.,2000.,2400.,3000.,3500.,4000.,4500.,5000.,
5500.,6000.,6500.,7000.,7500.,8000.,8500.,9000.,9500.,10000.,
 EDMH=1.0,1.0,1.0,.98,.95,.91,.84,.78,.70,.65,.60,.55,.52,.48,.44,.40,
.37,.33,.31,.31,.30,
 TAR=0,5000,10000,15000,20000,25000,30000,35000,40000,45000,50000,
55000,60000,65000,70000,72000,74000,76000,78000,80000,82000,
 YHIT=1.0,1.0,1.0,1.0,1.0,1.0,.98,.95,.88,.85,.82,.78,.70,.58,.49,
```

```
.45,.43,.42,.39,.38,.35,
 SPAC=.22,.47,.69,.86,.90,1.02,1.0,30*.,
 TPAC=.37,.61,.82,.96,1.05,1.06,1.0,30*.,
 ZPAC=.8,1.04,1.20,1.28,1.27,1.17,1.0,36*.,
 IDENT=1,1,1,1,2,2,2,2,3,3,3,3,4,4,4,4,5,5,5,5,6,6,6,6,7,7,7,7,8,8,8,8,
9,9,9,9,10,10,10,10,11,11,11,11,12,12,12,12,13,13,13,13,14,14,14,14,
15,15,15,15,16,16,16,16,17,17,17,17,18,18,18,18,19,19,19,19,20,20,20,
20,21,21,21,21,22,22,22,22,
 TEPAC=.25,.25,.25,.25,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,
.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.25,.25,.25,.25,.5,.5,
.5,.5,.25,.25,.25,.25,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,
.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.5,.25,.25,.25,.25,.5,.5,
.5,.5,
 TPLACE=10,10,10,10,40,40,40,40,70,70,70,70,100,100,100,100,110,110,
110,110,120,120,120,120,130,130,130,130,150,150,150,150,160,160,160,
160,170,170,170,170,200,200,200,200,210,210,210,210,230,230,230,230,
250,250,250,250,270,270,270,270,300,300,300,300,320,320,320,320,360,
360,360,360,380,380,380,380,400,400,400,400,420,420,420,420,460,460,
460,460,
 &END
C
C  DATA RED two
C
 &DATA2
 TCOND=22000,32000,18000,23000,100,100,100,100,100,100,100,100,3,4,2,2,
90,100,90,100,6,8,8,6,100,100,100,100,100,85,95,94,100,100,100,100,
299,452,245,288,100,100,100,100,22000,27000,21000,26000,100,100,100,
100,100,90,80,70,100,100,100,100,100,100,100,100,100,100,90,90,3,4,2,
2,100,100,100,100,100,100,80,95,35,32,33,30,6,8,8,6,
 GTIME=0.,
 SUM=0,
 IX=54,
 IX1=89,
 IX2=98,
 IX3=454,
 IX4=247,
 &END
```

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